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Public participation and trust in nuclear power development in China

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A B S T R A C T

Rapid expansion of nuclear power in China requires not only increasing institutional capacity to prevent and adequately cope with nuclear risks, but also increasing public trust in governmental agencies and nuclear enterprises managing nuclear risks. Using a case study on Haiyang nuclear power plant in Shandong province, public participation, communication, information disclosure and trust regarding nuclear policy and industry are investigated among Chinese citizens living close to nuclear facilities. The results show that development and decision-making on nuclear power are dominated by an 'iron nuclear triangle' of national governmental agencies, nuclear industries, and research organizations. The public, media and NGOs are neither informed nor involved. In contrast to low levels of public trust in governmental authorities advocating nuclear energy in western countries after Fukushima (Japan), Chinese respondents have still high levels of trust in governmental authorities (but not in state-owned nuclear power companies) regarding nuclear information provision, emergency response to nuclear accidents, and decision making on the country's nuclear future. A proven record in risk management and lack of alternative information sources explains this trust. As overall trust and credibility in China's governmental authorities is waning, and absence of transparency and public scrutiny proved fatal in Fukushima, the Chinese government has to develop a strategy for public involvement and information disclosure in nuclear power development in the post-Fukushima era.

Contents

1. Introduction

On October 19, 2011, the Chinese State Council instigated the formulation of a Social Credit System Plan. According to the State Council two major factors are hindering the progress of the Chinese society: lack of credibility of society and lack of public trust in the government [1]. This analysis is shared among broader constituencies: in recent years credibility and trust have become much-discussed concepts among Chinese (high-level) government officials as well as the public. A survey on "credibility among Chinese people" showed that the aggregate credibility index has remained stable at a low level since 2005 [2]. And many

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of the more than 180,000 annual protests in China are related to a lack of trust in and credibility of local governments and the prevailing economic system.

Environment and health risks are one of the core areas where lack of credibility and trust has become prominent in China. A steady flow of food safety incidents, numerous accidents in industrial plants and ongoing pollution of water, air and land have severely decreased public trust in and credibility of governmental institutions and state-owned private companies [1,3,4]. One of the actions taken by the Chinese government in trying to turn the tide of distrust is the 2008 Open Governmental Information Regulation, and its related 2008 Environmental Information Disclosure Decree [5–7]. Open access to and open government communication on environmental risks can reduce feelings of anxiety and distrust. In numerous OECD countries, well-institutionalized right-to-know legislation and information disclosure provisions have indeed increased credibility of private and public institutions and reduced distrust [8–10]. One notable exception where many OECD countries still face lack of credibility and distrust is in the field of nuclear power. Several investigations show still major anxieties and distrust among the public towards nuclear power policies, companies and installations, constantly reinforced through nuclear accidents such as Three Mile Islands (USA, 1979), Chernobyl (Ukraine, 1986), and recently Fukushima (Japan, 2011).

Hence, one would expect to find similar degrees of distrust in nuclear power related companies and governmental agencies in contemporary China, certainly shortly after the nuclear disaster at Fukushima and at places relatively close to Chinese nuclear facilities (under construction). This research investigated public trust towards nuclear policy and industry among Chinese citizens living close to nuclear facilities, and whether and how communication and information disclosure (can) play a role in mitigating lack of credibility and trust. The next section reviews the literature on trust in nuclear power and relates that to China's civil nuclear program. Section 3 reports on the selected case study (Haiyang nuclear power plant), the research methods, and data collection strategy. The three subsequent sections report on the development of and communications on the Haiyang nuclear project, public information access and participation in that project, and the trust and confidence among the public in the project. The final section presents the conclusions.

2. Nuclear power, risks and trust

2.1. Experiences of OECD countries

In many OECD countries nuclear technology has been associated for a long time with small and larger technological failures and accidents (Three Mile Island, Chernobyl, Fukushima), environmental risks associated with radioactive waste disposal, and distrust in responsible and involved state and private institutions [11,12]. Major reactor accidents of nuclear power plants are rare, yet the consequences are catastrophic. An accident risk assessment of nuclear power plants (NPPs) by the US Nuclear Regulatory Commission in 1975 estimated the probability of a core meltdown at 1 in 20,000 per year for a single reactor unit [13]. A follow-up report in 1990 indicated that the probability would be roughly 1 in 100,000 [14]. According to the latest results, a nuclear meltdown in one of the reactors (the most severe event on the International Nuclear Event Scale, INES 7) in operation worldwide is likely to occur once in 10 to 20 years—some 200 times more often than estimated in the past [15]. The results show that Western Europe is likely to be contaminated about once in 50 years by more than 40 kilobecquerel of caesium-137 per square meter. The 2011 nuclear disaster and meltdown in Fukushima make these recent accident risk assessments quite realistic.

In the 1970s and 1980s, following Three Miles Island and Chernobyl, social scientists found a steady decline of support for nuclear industry among the public [16]. More recent polls during the first decade of the new Millennium showed that fifteen years after Chernobyl opposition against nuclear power had faded in many OECD countries [17,18]. With the growing importance of climate change nuclear power started to be reframed as a solution to a problem, rather than the source of a problem, leading to more positive attitudes to nuclear technology [18,19], though it was a 'reluctant acceptance' [20]. The nuclear accident in Fukushima, Japan, change that again.

It is widely reported that the construction of new nuclear facilities is often heavily opposed by the communities where these are planned [21], but communities that have already nuclear facilities seems to perceive these more favorable due to specific (economic) benefits obtained, a process of distancing from local risks and hazard, and processes of familiarization and normalization of nuclear risks [22,23].

One of the key challenges around nuclear power in OECD countries has been (lack of) trust in the regulators, governments and industries promoting nuclear power [24]. Secrecy, lack of transparency, partial information provision, and a number of accidents have had strong effects on the levels of trust of citizens in regulating authorities, governments and owners and operators of nuclear industries, and in the information provided by these actors [25,26]. Overall, information provided by scientists, international organizations on nuclear energy, non-governmental organizations (NGOs) and nuclear safety authorities is most trusted, while national governments, companies operating nuclear power plants and family and friends are not considered reliable sources of information. Lessons learned from the history of nuclear power on transparency and public involvement are not always included in current plans for expansion, siting and waste handling of new nuclear power capacity, missing opportunities for more legitimacy, trust and acceptance of nuclear power and its risks [27]. Trust-based risk communication played key functions in alleviating public concerns, inducing attitudinal and behavioral changes, and resolving risk-related conflicts [28,29].

2.2. Nuclear power decision-making and supervision in China

Recent years have seen a marked expansion of nuclear development in China. With 15 nuclear power reactors in operation, 26 under construction (more than 40% of the world's total plants under construction) and many more being planned, China is just at the start of a nuclear era. Although the Fukushima accident caused a comprehensive safety check of all nuclear projects, and a temporary moratorium on further construction, the approval of *China's Medium- and Long-term Nuclear Power Development Plan* (*2011–2020*) and *Nuclear Power Safety Plan* (*2011–2020*) by the State Council on 24 October 2012 indicated a restart of nuclear power development [30]. According to the *12th Five-year Plan on Energy Development* (2011–2015) issued by the State Council on 1 January 2013, the installed capacity of nuclear power is expected to reach 40 million kW by 2015, an annual increase of 30% from 2011 to 2015. From the outset, there has been a governmental awareness of the potential hazards of generating electricity with nuclear power. Nuclear power safety depends on the same factors as in any complex industry, among which intelligent planning, proper design with safety margins and back-up systems, high-quality components and a well-developed safety culture. China implemented the principle of 'safety first' in the entire process of nuclear power development. The legal system, technical standards, safety management

mechanism, the supervision system, and an emergency mechanism for nuclear accidents have been established and improved to enhance the country's nuclear safety capability [31]. China's civil nuclear program is governed by a closed policy community—an 'iron nuclear triangle'—of government organizations, state-owned nuclear industry, and research institutions (see Fig. 1). A wide variety of government agencies—often with overlapping responsibilities—play a role in planning, approving, and licensing reactor projects, while the nuclear industry plays a major role in implementing nuclear energy plans. The State Council is the supreme institution for strategic polices and planning of nuclear energy. The powerful NDRC is responsible for drafting the nuclear development plans and the selection of appropriate nuclear power plant construction projects. The National Energy Administration (NEA) conducts the daily work of the new National Energy Commission (NEC), under the authority of NDRC. The National Nuclear Safety Administration (NNSA), under the Ministry of Environmental Protection (MEP), is the key administrative body that licenses, regulates, and supervises nuclear power plant operation. Despite more than 20 years of nuclear development, China has not established a systematic legal system to govern the safe use of nuclear energy [32]. NNSA is responsible for developing policies, regulations, and standards for nuclear safety and radioactive materials; drafting nuclear emergency response plans; implementing nuclear accident investigations; and conducting radioactive environmental monitoring. Local Offices of Nuclear and Radiation Safety Management (ONRSM), within Environmental Protection Bureaus (EPBs), are responsible for the local nuclear power supervision outside of the nuclear power plants, including the radioactive monitoring and nuclear accident response plans. In case of accidents the National Nuclear Emergency Coordination Committee (NNECC), affiliated to the Ministry of Industry and Information Technology (MIIT), is responsible for nuclear emergency response. In July 2012, 16 provinces had established a provincial nuclear emergency response center. All these governmental organizations have multiple and often overlapping responsibilities and make up a complex and difficult to understand governance arrangement [33].

All nuclear enterprises are state-owned, under supervision of the State-owned Assets Supervision and Administration Commission of the State Council (SASAC). Only three state-owned enterprises are licensed to own and operate nuclear power plants: the China National Nuclear Corporation (CNNC), the China Guangdong Nuclear Power Corporation (CGNPC), and China Power Investment Corporation (CPIC). In addition to this "nuclear troika," the State Nuclear Power Technology Company (SNPTC), created in 2007, leads to nuclear power technology development and nuclear technology transfer from overseas. China International Engineering Consulting Corporation (CIECC) is the largest engineering consultancy and think tank of nuclear technology. Other investors (e.g. energy companies, financial institutions, provincial governments, etc.) participate in nuclear reactor projects, but they are not allowed to have majority shares in the projects. Plant owners and other industry players must now raise a majority of the finances for new plants, which give them some power to debate with national government authorities, such as the State Council and NDRC, on nuclear plant priorities and siting.

Nuclear energy research and engineering bodies consist of a variety of institutes affiliated with nuclear companies, the Chinese Academy of Sciences, and a few universities, including Tsinghua University, Beijing University, Xiamen University, Xi'an Jiantong University, and Shanghai Jiaotong University. Experts of these research institutes advise governmental agencies and play a major role in Environmental Impact Assessments [34]. More than

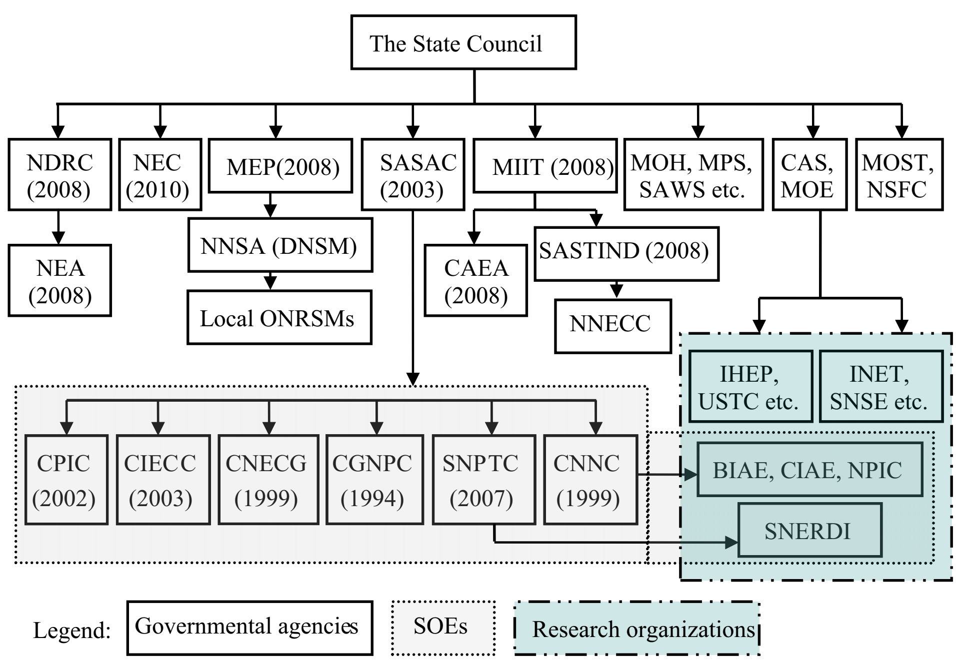


Fig. 1. Main organizations in China's 'iron nuclear triangle'. *Note*: The number in parentheses is the latest date of establishment or restructuring. BINE: Beijing Institute of Nuclear Engineering; CAEA: China Atomic Energy Authority; CAS: Chinese Academy of Sciences; CGNPC: China Guangdong Nuclear Power Corporation; CIAE: China Institute of Atomic Energy; CIECC: China International Engineering Consulting Corporation; CNECG: China Nuclear Engineering Construction Group; CNNC: China National Nuclear Corporation; CPIC: China Power Investment Corporation; DNSM: Department of Nuclear (Radioactive) Safety Management; IHEP: Institute of High Energy Physics, Chinese Academy of Sciences; INET, Institute of Nuclear and New Energy Technology, Tsinghua University; MEP: Ministry of Environmental Protection; MIIT: Ministry of Industry and Information Technology; MOE: Ministry of Education; MOH: Ministry of Health; MOST: Ministry of Science and Technology; MPS: Ministry of Public Security; NDRC: National Development and Reform Commission; NEA: National Energy Administration; NEC: National Energy Commission; NNECC: National Nuclear Emergency Coordination Committee; NNSA: National Nuclear Safety Administration; NPIC, Nuclear Power Institute of China; NSFC: National Natural Science Foundation of China; ONRSM: Office of Nuclear and Radiation Safety Management; SASAC: State-owned Assets Supervision and Administration Commission; SASTIND: State Administration of Science Technology and Industry for National Defense; SAWS: State Administration of Work Safety; SNSE: School of Nuclear Science and Engineering, Shanghai Jiaotong University; SNPTC: State Nuclear Power Technology Corporation; SNERDI: Shanghai Nuclear Engineering Research and Design Institute; SOE: State-Owned Enterprises; USTC: University of Science and Technology of China, Chinese Academy of Sciences.

Table 1
Enacted regulations on nuclear information communication in China.

Name	Promulgated organization
Decree on Safety Supervision and Management of Civilian Nuclear Facilities, HAF 001, 1986, amended 2007	The State Council
Ordinance on Nuclear Accident Emergency Management at Nuclear Power Plants, HAF 002, 1993, amended 2011	The State Council
Reporting Rules on Nuclear Power Plant Operating Units, HAF 001/02/01-1995	NNSA
Reporting Rules on Research Reactor Operating Units, HAF001/02/02-1995	NNSA
Reporting Rules on Nuclear Fuel Cycle Facilities, HAF001/02/03-1995	NNSA
Reporting Rules on Nuclear Accident Emergency at Nuclear Power Plant, 2001	SASTIND
Reporting Rules on Nuclear Power Project Construction, 2008	NEA
Reporting Rules on Nuclear Power Plant Operation, 2008	NEA
Program of Nuclear and Radiation Safety Information Disclosure (trial), 2011	MEP
Notice on the Strengthening of the Information Disclosure of Nuclear and Radiation Safety in Nuclear Power Plant, 2011	NNSA
Provision on Radiation Safety Management System of the National Nuclear Technology Use, 2012	DNSM
Interim Measures on Public Participation in the Environmental Impact Assessment, 2006	Former SEPA

Note: see Fig. 1 for abbreviations.

incidentally close ties and dependencies exist between experts from these institutes and governmental and industrial nuclear organizations. All in all, the public plays hardly any role in decision-making of nuclear energy development. Though the government adopted many measures to prevent damage to humans and the environment, it basically regards public participation irrelevant on nuclear issues.

2.3. *Nuclear power information disclosure and trust in China*

Since the first nuclear power plant was connected to the Chinese electricity grid in 1991, China's nuclear power plants have operated without any major safety incidents (level 2 or above), but there have been minor leakages resulting from poor equipment quality and operational failures. The regulation of information exchange and communication between governmental supervisors, power plant operators and the public are enacted in quite a number of regulations (Table 1). Regardless of the large number of regulations, in general the Chinese public is poorly informed about nuclear risks and risk management. Governmental authorities and enterprises rarely communicate and report on nuclear incidents or accidents to the public.

The first public protest against nuclear power plant construction can be traced back to the 1980s when Dayawan nuclear power plant was constructed. The Chernobyl accident in 1986 triggered major public protest against Dayawan in Hong Kong, involving 56 local groups and more than 1 million inhabitants, but it did not cause any construction delay or change [35]. In order to communicate with the public in Hong Kong, the Daya Bay Nuclear Power Station Safety Advisory Committee (known as the Nuclear Safety Advisory Committee of Daya Bay and Ling Ao Nuclear Power Plants since 2008) was founded in 1988, comprising mainly Hong Kong professionals and social celebrities.

Debates about the Rushan nuclear power project in Shandong Province in 2007 indicated that public awareness of nuclear risks was increasing and spreading. Internet blogs, the national media networks, and non-governmental organizations (NGOs) triggered an intensive local debate about the project [36]. Risks associated with poor supervision and transparency of the Rushan project also alarmed domestic (and international) analysts [37] and these protests eventually brought the project to a temporary halt. Still, the lack of domestic reporting on the recent radioactive leak at the Dayawan plant on May 23, 2010, illustrates that transparency and communication with the public on nuclear issues is far from institutionalized in China [38,39].

The recent Fukushima nuclear accident challenged nuclear information dissemination by the Chinese government as well as public trust in the Chinese government. The country wide panic in buying salt seems to indicate that both public knowledge on nuclear risks and public trust in governmental information provisioning was lacking. In reaction to growing public uneasiness, China's environmental minister took the lead in stressing the importance of increasing information transparency in case of such nuclear accidents and—more in general—of public involvement in decision making processes on nuclear power [40]. Hence, to allay public uneasiness and maintain social stability the national government released numerous files on the Fukushima accident, including 121 news messages, 300 series of radiation monitoring data, 23 series of integrated information of radiation monitoring, 20 articles on nuclear and radiation science, and 78 Chinese translations of Japan's *Fukushima Nuclear Disaster Reports* published by the Japanese Nuclear and Industrial Safety Agency. On 1 April 2011, the *Program of Nuclear and Radiation Safety Information Disclosure* (*trial*) (issued by MEP), and the *Notice on the Strengthening of the Information Disclosure of Nuclear and Radiation Safety in Nuclear Power Plants* (published by the NNSA) further promoted and standardized the information disclosure on nuclear and radiation safety.[1] From March to December 2011, the NNSA and other relevant departments conducted a comprehensive safety inspection of all civil nuclear facilities and developed the *2020 Vision Goals of Nuclear Safety and Radioactive Pollution Prevention and Control* (hereafter the Plan). In May 2012 the State Council approved the Plan and the *Report on Comprehensive Safety Inspections of Civilian Nuclear Facilities*. According to the new Plan, the investment in nuclear power safety improvement, radiation pollution control, research and technology innovation, and emergency response will amount to 79.8 billion RMB (11 billion US$) till 2015. The Plan and the Report have been released to the public for commenting through the MEP website, be it only for 10 days (from 19 to 29 June, 2012) as is standard for Strategic Environmental Assessment commenting. The public participation section of the Plan announced the development of nuclear facility information disclosure; detailed the scope, responsibility and procedure of information openness by the government and the company; and called for increase in public participation throughout the life cycle of nuclear facilities. This at least acknowledges the need to open up the closed nuclear policy community in order to build trust and public participation in China's nuclear power development.

Little systematic knowledge exists about current public trust in the 'iron nuclear triangle' managing nuclear technology in China [41–44]. Pre-Fukushima national surveys during five years

[1] The Dayawan Nuclear Power Operations Management (DNMC) formulated and promulgated *Measures on Nuclear and Radiation Safety Information Reporting and Open in Nuclear Power Plant* in September 2011. On 15 December, 2011, the first specific nuclear information webpage by DNMC was online as trial (available at http://www.dnmc.com.cn/n29036/n4898793/n4917959/index.html).

(2002–2006) on the public acceptability of nuclear power showed that over 80% of the Chinese public (strongly) supported the national development of nuclear power, but less than 50% of the public agreed with developing nuclear power in their hometown (Internal reports of the INET, 2003–2007). Similar surveys in Beijing and Guangdong province presented a lack of public awareness and knowledge about nuclear power, and a tendency to support the development of new nuclear power plants but 'not in my back yard' [45].

3. Data collection and analysis

To better understand public rust and credibility in nuclear power in China we carried out an empirical study in the communities around the Haiyang nuclear power plant in Shandong province three months after Fukushima (see Fig. 2).

In 2007, Haiyang nuclear power project was listed in *China's Medium- and Long-term Nuclear Power Development Plan* (2005–2020) and construction of the first two (of the planned six) reactors started in September 2009. To investigate risk communication and trust during construction of this nuclear power plant a survey was carried out in neighboring communities; websites of the local governments, Environmental Protection Bureaus (EPBs) and Shandong Nuclear Power Company (SDNPC) were analyzed; and 10 in-depth semi-structured interviews were held with representatives of EPBs of Shandong Province, Yantai City and Haiyang County, with representatives of Shandong Office of Science and Technological Industry of National Defense (OSTIND) and Liugezhuang Township Government, with directors of villages, and with an expert of Qinghua University.

There are 14 villages within 10 km from Haiyang nuclear power plant. Around 7300 and 15,000 residents live within 5 km and 10 km from the plant, respectively. After a pre-survey, three out of the 14 villages were selected at distances of 0.5 km, 4 km, and 8 km from the nuclear facility. The survey, carried out in June and July 2011 through face-to-face interviews, covered 240 randomly sampled residents in these three villages. The samples accounted for about 6% of the total number of residents (4080 people). The questionnaire had semi-open and closed questions, in three sections: (1) socio-economic and demographic variables; (2) risk information access and participation in the nuclear power project; and (3) trust in information sources and confidence in response capacities. A total of 226 valid questionnaires were returned (response rate of 94%). SPSS was used for statistical analysis of the survey data.

4. Development of and communication on Haiyang nuclear project

Shandong province is the second largest province in terms of GDP and population in China. The two digits GDP growth over the last two decades is fueled by coal-fired electricity. In 2010, a gap of 20 million kW existed between power demand and power supply capacity in Shandong Province. This power shortage challenged local economic development. According to the 12th Five-Year Plan of Economic and Social Development in Shandong Province (2011–2015), the proportion of coal-fired electricity will have to decrease from 92% to 71%. The development of nuclear power plants in Haiyang and in Rongcheng is part of this policy. Local governmental authorities used various media (internet, newspaper, and TV) to inform the public that nuclear power was a safer way to produce electricity than coal-fired power generation, and they emphasized the advantages and benefits of nuclear power. The construction of Haiyang nuclear project has a history of 20 years (see Fig. 3). Around 1983, Shandong Nuclear Power Plan Group (organized by Shandong Electric Power Industry Bureau and Shandong Electric Power Design Institute) started to investigate new nuclear power plant sites along the Coast of Huanghai Sea and selected six priority sites, including Haiyang and Rongchen. Haiyang was considered a suitable site for nuclear power plant construction due to its favorable geological, hydrological, and meteorological conditions. After a preliminary feasibility study, a feasibility study, site planning and technology selection, the preparatory work of the first stage project was approved by the NDRC and the State Council in 2007 and engineering formally started. The project adopted advanced technology—AP1000 pressurized water reactors—with high safety levels. Shandong Nuclear Power Company (SDNPC) as sub-company of the CPIC was established in September 2004 and was responsible for the design, operation, and management of Haiyang nuclear power project. The start of the second construction stage received approval of NDRC and State Council in 2009. The first two reactors, with a total investment of 40 billion Yuan (about 6.5 billion US$), will be commercially operational in 2014 and 2015, respectively. Annual generation capacity will reach 17.5 billion kWh. The total investment of Haiyang nuclear project will reach 100 billion Yuan (over 16 billion US$). It will be the largest nuclear project in China after all six reactors are in operation. During the entire process, national agencies—especially the State Council and NDRC—have been key decision makers, while the power agencies and companies have been key implementers. The NNSA is the main inspecting department for site selection, construction, commissioning, operation,



Fig. 2. Location of Haiyang Nuclear Power Plant in Shandong Province, China.

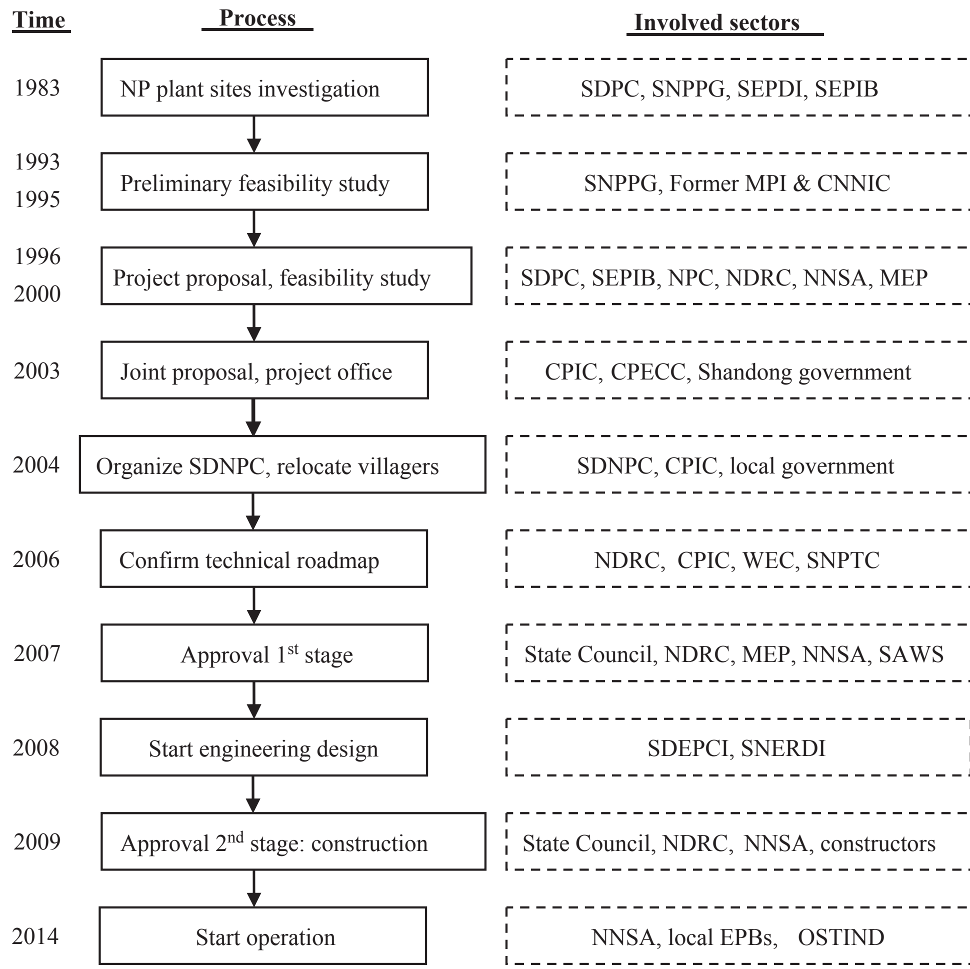


Fig. 3. Process of Haiyang nuclear power construction and the involved organizations. *Note*: CNNIC: China National Nuclear Industry Corporation; CPECC: China Power Engineering Consulting (Group) Corporation; MPI: Ministry of Power Industry; NPC: National Power Corporation; OSTIND: The Office of Science and Technological Industry of National Defense in Shandong; SAWS: State Administration of Work Safety; SNERDI: Shanghai Nuclear Engineering Research and Design Institute; SDEPCI: Shandong Electric Power Engineering Consulting Institute; SDNPC: Shandong Nuclear Power Company; SEPIB: Shandong Electric Power Industry Bureau; SNPPG: Shandong Nuclear Power Plan Group; SEPDI: Shandong Electric Power Design Institute; SDPC: Shandong Planning Commission; WEC: Westinghouse Electric Corporation.

and decommissioning. During operation of the nuclear power plant, NNSA plays a key function for safety supervision and inspection of this nuclear facility.

Local governments have been main promoters, have different responsibilities and carried out various measures (Table 2). The Office of Nuclear and Radiation Safety Management of Shandong EPB was founded only in 2009, with responsibilities for radiation prevention and control and radiation monitoring outside the nuclear power plant. Emergency management of the nuclear power plant was designated to the Shandong Commission of Science Technology and Industry for National Defense. The EPBs of Yantai city and Haiyang city also established Offices of Nuclear and Radiation Safety Management. Local EPB officials rarely participated in decision making processes on local nuclear power and these local supervisors have no authority to inspect and monitor the internal management of the Haiyang nuclear power plant. After the Fukushima nuclear accident, the Shandong Nuclear and Radiation Safety Monitoring Center and local EPBs conducted emergency radiation monitoring and published the data through the Internet, TV, and newspapers. From July to August 2011, the MEP, NNSA, NEA and China Earthquake Administration conducted a comprehensive safety inspection of Haiyang nuclear facilities. An inspection team of more than 50 experts was divided in four groups: external events, major accidents, emergency response, and engineering design and management. They checked and evaluated twelve security aspects of the nuclear facilities construction.

For analyzing communications and information dissemination of SDNPC (the owner and operator of the Haiyang project) with other state and non-state organizations, news and documents were collected through SDNPC website and through interviews. The temporal distribution of communications showed that the number of communications increased after the project preparation was approved by the NDRC in 2007 (see Fig. 4), and especially in 2010 when the construction formally started. SDNPC communicated most frequently with domestic companies (nuclear power companies, nuclear design institutes, equipment building companies etc.), the State Council and ministerial agencies, and Shandong provincial government and its departments (see Fig. 5). The content mainly related to technical/equipment problems and project development. SDNPC hardly communicated with and informed the media, the public and international organizations.

5. Public information access and participation on nuclear power

For most industrial companies provincial and municipal EPB officials can obtain environmental information from higher or

Table 2
Measures taken by local governmental agencies on nuclear power plant supervision in Shandong.
(*source*: interviews).

Organization	Institution and actions
Shandong EPB	– Enacted Administrative Rules on Radiation Environment of Shandong Province 2003 – Established Division of Nuclear and Radiation Safety Management – Established Nuclear and Radiation Safety Monitoring Center – Conducted background radiation monitoring around Haiyang nuclear power plant in 2010 – Developed radiation environmental safety control system in 2011 – Conducted radiation emergency monitoring after Japan nuclear crisis – Developed 12th Five-Year Plan of Nuclear and Radiation Safety Supervision, Shandong Province – Responsible for supervision monitoring of nuclear facilities safety – Participate in nuclear accident response
Shandong OSTIND	– Established Nuclear Emergency Management Center – Promulgate and implement emergency response policy and plan – Organize and coordinate emergency management of the nuclear accident – Build Shandong Nuclear Emergency Command Center in 2011
Yantai EPB Haiyang EPB	– Established Office of Nuclear and Radiation Safety Management – Implement national policy and regulation on nuclear power – Conducted radiation emergency monitoring after Japan nuclear crisis – Draft emergency plan of nuclear accident – Supervise nuclear facilities safety – Undertake daily work of Office of the Nuclear Accident Emergency Coordination Committee
Yantai city government	– Enacted Opinions on Accelerating the Development of Nuclear Power Industry in 2008 – Established Lead Group of Development of Nuclear Power Industry
Haiyang city government	– Established Office of Nuclear Power Construction in 2003 – Enacted Opinions on Accelerating the Development of Nuclear Power Industry in Haiyang – Enacted Plan of High Level Industry Development in Haiyang – Built nuclear facility industry park in 2009

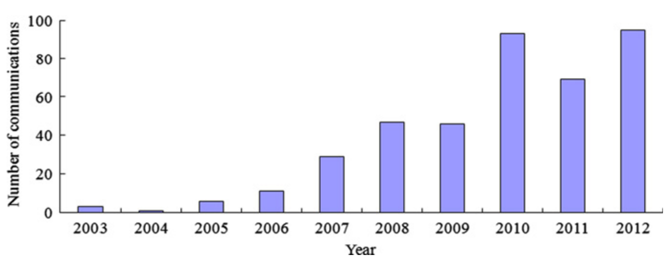


Fig. 4. Temporal distribution of communications of SDNPC on the Haiyang nuclear power project (2003–2012).

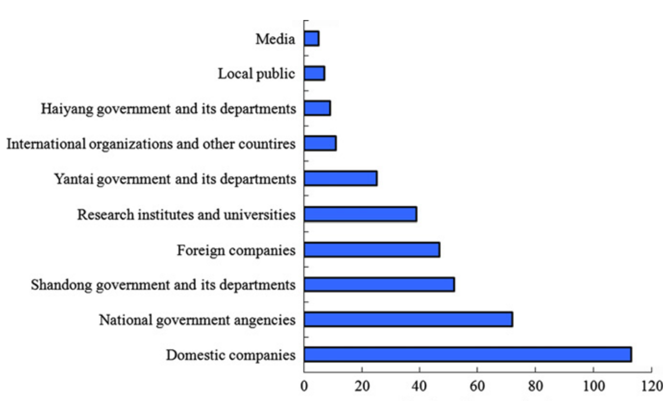


Fig. 5. Organizations targeted by SDNPC communications on Haiyang nuclear power project (2003–2012).

lower level governmental agencies and from companies themselves, in the form of documents, datasets and reports. These EPBs are responsible for the disclosure of relevant information to the public. However, with respect to Haiyang nuclear power plant EPB officials proved to have only limited data available and hardly any information disclosure authority. In China, data and information on nuclear energy planning, nuclear power plant construction, operation, emissions and accidents are 'owned', managed and controlled by national agencies and by state-owned companies. The State Council and NDRC dominated energy planning, including the nuclear power development. Information on nuclear accidents and risks is in the hands of national organizations, which are authorized by the State Council, and these national entities decide on dissemination of information through the official media: governmental websites and/or the state news agency. The interviewed provincial and municipal EPB officers in Shandong obtained most information on nuclear energy planning, accidents and risks from the media, especially from the websites of NNSA and CAEA. Local government officers and village leaders obtained information from the TV, newspapers and through the Internet. Governmental authorities at various levels advocated energy development plans for their contribution to social and economic development. The local public was not well informed on nuclear energy.

Citizens around Haiyang obtain general information on nuclear power and on nuclear radiation levels and risks mainly from the media (78%)—especially TV (61%) and the Internet (13%)—and to a lesser extent directly from scientific institutions (11.5%) and from relatives and friends (6%). Governmental authorities (2.2%), environmental NGOs (0.9%), international organizations (0.9%), and nuclear power companies (0.4%) hardly play a role in direct information provisioning to the public on nuclear power and radiation risks (see Fig. 6).

More specifically on Haiyang nuclear power plant, about 74% of the respondents knew about the construction (plan) of the

nuclear power plant nearby their villages since 2000. Nearly 46% of the respondents obtained that information from relatives and friends, followed by media (20%) and governmental bulletins (12%). Experts, environmental NGOs and the SDNPC were less important information channels for the public.

Public participation has been very limited in the entire process of Haiyang nuclear power plant siting, environmental impact assessment (EIA) and plant construction (Table 4). According to the 2003 *Law of Environmental Impact Assessment* and the 2006 *Interim Measures of Public Participation in Environmental Impact Assessment*, public participation is a mandatory element in EIA. The SDNPC and the EIA implementing organizations conducted a one time survey on the construction of the nuclear power plant among citizens located in the vicinity of the construction site (normally $n=100$–300). The SDNPC also communicated four times (in July and August 2008, and in May and June 2009) an Environmental Impact Assessment (EIA) bulletin on Haiyang nuclear power project through the SDNPC website, the Yantai City governmental information website, the Shuimu website, the Yantai Daily, and the local Qilu Evening News. The SDNPC also held a panel discussion about Haiyang nuclear power project EIA on 12 June, 2009. In total 28 representatives from Haiyang governmental agencies, the residents around the nuclear power plant, and the EIA agency participated in the panel and provided (limited) comments on the EIA report. The research team was denied access to the results of the survey, as well as to the report of the panel discussion, and to the EIA judgment. Through the implementation of the EIA survey, over 18% of the respondents had gained knowledge about the EIA and 12% of them participated in it. The majority of the respondents, however, felt that they were not asked directly to give their opinion on site selection and the construction of Haiyang nuclear power plant. They were neither informed on nuclear power plant risks, nor did they feel enabled to communicate directly with the ‘iron nuclear triangle’ on ideas for nuclear power plant construction (Table 3).

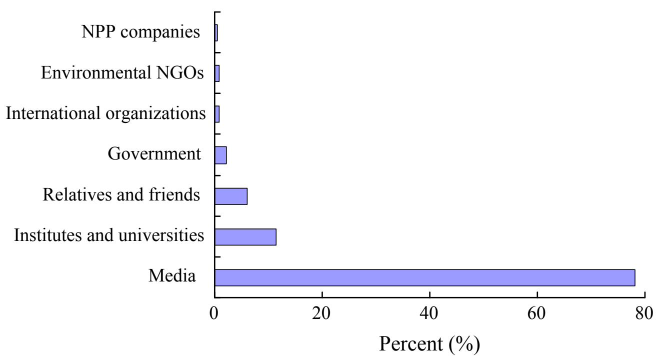


Fig. 6. Used information sources of nuclear power and risks by respondents ($n=226$).

Before the start of the process leading to the construction of the Haiyang nuclear power plant 7295 residents lived within 5 km distance to the planned facility. More than 2500 residents from two villages (Lengjia village and Dongjia village) around the construction place had to move to a new area more distant from the construction site. In 2003, the Haiyang Office of Nuclear Power Construction was established and assisted with the relocation of residents from the two villages around the nuclear power plant. The Haiyang Bureau of Finance, the Bureau of Audit, and the Office of Demolition and Relocation (ODR) issued the *Scheme on*

Table 3
Public participation in the construction of local nuclear power project.

	Yes (%)	No (%)
Were you asked to give your opinion on site selection of NPP?	4	96
Were you asked to give your opinion on the construction of nuclear power plant in your local area?	11	89
Were you informed on nuclear power plant and its risks?	7	93
Did you know about the EIA of the nuclear power plant?	18	82
Did you participate in the EIA of the nuclear power plant?	12	88
Could you communicate with local governments or the nuclear power company on ideas about NPP construction?	8	92

Table 4
Main reasons to trust information sources from and confidence in response capacities of different actors in case of a nuclear accident in China ($n=226$).

	Trust in information		Confidence in response capacity	
	Reasons	Percent (%)	Reasons	Percent (%)
Who	*Government*		*Government*	
	Authoritative source of information	14.2	Has the capacity to respond and solve the crisis	23.4
	Provides more reliable information than other actors	10.5	Cares about and represents public interests	19
	Has the capacity to collect and publish the information.	9.1	Previous accidents verified it is trustful and reliable	16.4
	Is responsible for information disclosure	9.1	Authoritative organization for public interests	11
	Is only trustful source, others are not reliable	6.2	Strong and effective capabilities for accident response	6.3
	Is the leading organization	2.2	Responds timely and quickly	3.9
Who	*Institutes & universities*		*International organizations*	
	Master science and knowledge on nuclear power	12	Objective and strong	3.5
	Have capacity to access information	2.2	Can mobilize international power and capacity	2.7
	Are objective.	3.5		
	Are reliable	2.2		
Who	*Media*		*Nuclear power companies*	
	Provide timely information	6.6	Comply with and implement governmental orders	2.4
	Present governments voice and inform the public.	5.8	Know internal and real situation	2.1
	Correct and reliable information	4.3	Have high technical capacity	1.8
	Provide large amounts of information	1.3		

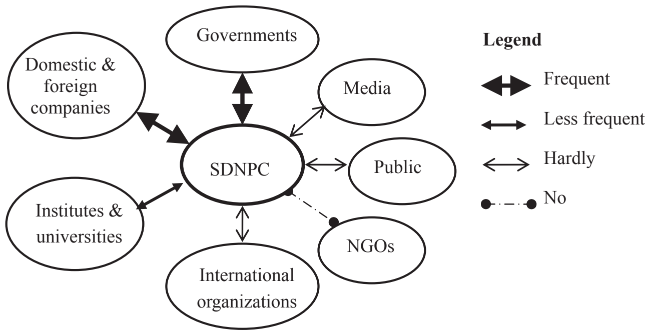


Fig. 7. Communication and information exchange between SDNPC and stakeholders in the development of Haiyang Nuclear power project.

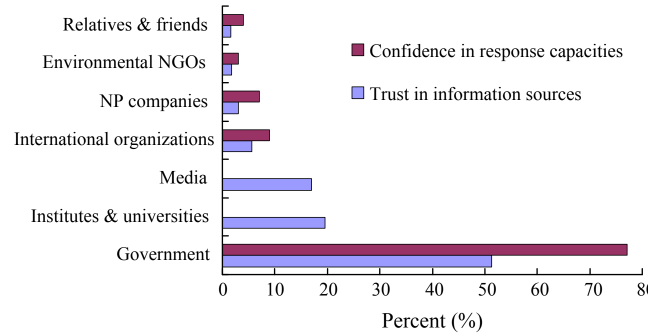


Fig. 8. Trust in information sources and confidence in response capacities of the different sectors in case of a nuclear accident in China (n=226).

*Land Acquisition and Relocation Compensation of Haiyang Nuclear Power Projec*t in March 2004. The compensation agreements between the ODR and the relocated households were signed from 6 to 23 April, 2004. The local government motivated the villagers to relocate on the condition that the government helped them to build new houses and provided them compensation. From 25 April 2004 to 23 April 2005, 1042 households and more than 10 enterprises moved to new places. Now Shaojia village (318 inhabitants) and Zhangjia village (1210 inhabitants) are the villages closest to the construction site, about 0.5 km from the Haiyang nuclear power plant. About 30% of the relocated respondents complained that their income reduced after relocation, because they could no longer be engaged in fisheries and marine culture. Most respondents in Shaojia village indicated that they were affected by the noise of the nuclear power plant construction and worried about nuclear accidents similar to the Fukushima nuclear crisis.

In conclusion, the 'iron nuclear triangle' of national government, industries, and research organizations had frequent and regular interactions and information exchanges on safety, finance, technology, human resources, and supervision and management. The public, the media, international organizations and NGOs were hardly involved in any communications and information exchange on the project (see Fig. 7).

6. Trust in information sources and confidence in response capacities

The *Decree on Environmental Information Disclosure*, enacted in 2008, has no clause on information openness of nuclear power, radiation safety, and its risks. In response to the chaos following the Fukushima crisis, the Program and the Notice on nuclear safety information disclosure (see Table 1) were enacted by MEP and NNSA, respectively. After the Fukushima nuclear crisis, environmental protection agencies throughout China conducted emergent radiation monitoring and disseminated these data through the Internet, TV, radio, and newspapers to facilitate public understanding of the situation and to prevent panic. For instance, the Ministry of Health issued—through various media—a Radiological Protection Guide to help the public to understand the risks and provide them knowledge on prevention. However, anxiety has been growing in China over the potential harmful effects of radiation emissions from Fukushima, despite repeated governmental announcements that the country faced no imminent health threat. In reaction to the potential radioactivity from Japan's crippled nuclear power plant, about 15% of our respondents took private actions such as buying salt, consuming cydiodine tablets, and not eating sea fish, spinage and seaweed. The main reasons given for taking such individual actions were lack of authoritative and trusted information, and preventive self-protection. Almost 47% of the respondents believed that the Japanese nuclear accident would not affect China, the others had serious doubts or thought it would affect China.

In case of a nuclear power accident (domestically or international) most respondents considered the government a trustful source of information on the accident (51%), followed by research institutes and universities (20%) and the media (17%). Relatives and friends were widely conceived as a not very trustworthy information source (Fig. 8). In case of a nuclear crisis respondents would place especially confidence in the responsive capacities of the government (77%) and to a marginal extent in international organizations (9%), and nuclear power companies (7%) (see Fig. 8). This is quite remarkable, and contrasting most OECD studies on nuclear power and accidents.

The main self-reported reasons for citizens' trust in governmental and nuclear company sources of information are summarized in Table 4. According to citizens, governmental authorities perform better than other organizations involved in nuclear energy, are more reliable than others, and have the capacity and authority to collect and publish relevant information. The reasons for such a high level of confidence in government are mainly related to its capacity to respond, the general idea that the government acts in the public interest, and its proven responsive record in former crises (Table 4). The relatively high trust in information from research institutes and universities in case of an accident relates to the fact that the experts master nuclear science and knowledge, and that their information is objective and reliable. Over 6% of the respondents trusted the national media, because of their timely, authoritative, correct and reliable information provisioning.

Pearson correlations analyses indicated that respondents with a lower level of education had significantly more trust in governmental information ($p<0.01$) and confidence in the governmental response capacities ($p<0.05$). Also village leaders had significantly more confidence in governmental response capacities ($p<0.05$). Respondents located at larger distance from the nuclear power had significantly more trust in governmental information ($p<0.05$). Gender, age, and income showed no significant differences in trust and confidence in the government.

7. Conclusion

The Fukushima Daichi crisis in Japan had a profound effect on world's nuclear power, nuclear policy and public perceptions of nuclear power risks. Secrecy, confusing information and distrust marred Japan's response to the crisis. But according to quite a few analysts lack of transparency and public participation is also at the cause of Japan's nuclear regulatory failures [46]. The incident

in the Daichi nuclear power plant still has its impacts. On 16 July 2012 an estimated 170,000 people packed in central Tokyo for Japan's biggest anti-nuclear rally to protest the restarting of nuclear reactors in Japan. And many western economies are reconsidering their stance towards and reliance on nuclear energy. However, at the 2012 Seoul Nuclear Security Summit the Chinese government continued to consider nuclear power irreplaceable for climate change mitigation and energy security. In contemporary global nuclear power, China stands out as a particular case as it is rapidly developing its nuclear industry, has not witnessed severe protests or major public debates on nuclear power, and has not really changed its lack of transparency and public participation on nuclear power development.

This case study into the current public participation and information disclosure around the planning and construction of one nuclear power project showed that decision-making on nuclear power is dominated by a closed 'iron nuclear triangle' of national governmental agencies (especially State Council, NDRC, NNSA), state-owned nuclear enterprises and scientific experts. Local governments are promoters and implementers of nuclear projects, but play hardly a role in decision-making and information dissemination. In all this the public has no corresponding voice and is hardly informed and involved in nuclear power developments; and neither are NGOs. Public participation and public access to information on nuclear constructions and assessments have been marginal [34,46]. Given this and the fact that high-level Chinese officials interpret lack of trust in the government as one of the key problems of contemporary China, it is remarkable that the public places high levels of trust in governmental information and confidence in governmental emergency response capacities. As information on nuclear power and related risks is very restricted in China, Chinese citizens tend to choose the government as the most trustworthy source when it comes to information provision on nuclear risks and accidents, and regarding responses to nuclear accidents. The government's dominant role in determining the country's developments, its authoritarian rule and capacity, its past record in handling other disasters (such as the Earthquake in Sichuan in 2008), and the absence of reliable and verifiable alternative information sources may account for this trust in the Chinese government. Chinese citizens have similar low levels of trust in nuclear power companies as the public in OECD countries.

This special, trusted, position of the government seems to relate also to the issue at stake—nuclear energy. As with respect to numerous other environmental risks (water pollution, chemical plants, incinerators, air pollution) evidence points at low levels of trust in (local) governments, nuclear power plants seems to be an exception. The highly scientific–technological character of nuclear risks, the centralized 'control' and responsibilities (with no major role for local governments), and the close relation with national priorities and agendas made nuclear power developments quite unlike any of the other environmental risks.

The Fukushima crisis has shown that a lack of transparency, public participation and public scrutiny can have severe consequences. In the absence of countervailing powers and public accountability closed communities can develop lock-in construction and design, are more vulnerable for corruption[2], and can serve only particular interests rather than public interests. Especially with respect to nuclear power development this lack of transparency and public participation is a high-consequence risk, which the Chinese government should not take.

[2] In 2010 the CEO of one of the leading Chinese nuclear companies was sentenced for accepting at least USD 1 million in bribes. Corruption may result in suboptimal construction and information distortion.

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